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DOI: https://doi.org/10.1037/pag0000246

Cognitive Complaints Mediate the Effect of Cognition on Emotional Stability across 12 Years in Old Age

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The authors declare no potential conflicts of interest concerning the research, the authorship, and publication of this article.

This publication is based on data from the Interdisciplinary Longitudinal Study on Adult Development (ILSE), funded by the German Federal Ministry for Family, Senior Citizens, Women, and Youth (Grant Ref. 314-1722-102/16 and 301-1720-295/2).

Abstract

Previous research supports a positive relationship between cognition and emotional stability, although findings regarding healthy older adults are inconsistent. Additionally, little is known about the mechanisms that underlie this association. Thus, the present study investigated the mediating effect of cognitive complaints on the bidirectional longitudinal association between cognition and emotional stability in old age. The study sample consisted of 500 older individuals (*M* age = 62.97 years, *SD* = 0.91, range = 60–64 years; 52% male) from the Interdisciplinary Longitudinal Study on Adult Development. The results showed that cognitive complaints mediated the effect of cognition on emotional stability over 12 years even when taking baseline emotional stability, baseline cognitive complaints, depressive affect, gender, sensory functioning, objective and subjective health into account. However, cognitive complaints did not mediate the effect of emotional stability on cognition. The results of the current study emphasize the importance of investigating cognition as a predictor of personality traits, and indicate that cognitive resources may serve as a protective factor for emotional stability in old age.

Keywords: cognition; cognitive complaints; emotional stability; old age; longitudinal mediation

Word count: 8375 (without abstract, references, tables, and figure)

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Cognition and personality traits are core domains of individual functioning across the life span. Both domains have in common that they are moderately heritable (cf. Briley & Tucker–Drob, 2017), and develop as a function of brain development, environmental demands, and individual experiences over the life span (e.g., Hofer & Alwin, 2008; Roberts & Mroczek, 2008). However, they show differential developmental trajectories over the lifespan: Cognitive functions (especially fluid abilities) tend to increase throughout early adulthood and then begin to show declines in old age (cf. Craik & Bialystok, 2006). Personality traits tend to stabilize in early to middle adulthood (e.g., Roberts, Walton, & Viechtbauer, 2006), and tend to slightly decrease in late life (e.g., Lucas & Donnellan, 2011; Wagner, Ram, Smith, & Gerstorf, 2016). Previous research showed some empirical evidence for smaller, and to some extent inconsistent cross–sectional and longitudinal associations between cognition and personality (see Curtis, Windsor, & Soubelet, 2015, for a review). Some researchers (e.g., Wettstein, Kuźma, Wahl, & Heyl, 2016) have pointed out that there is a general lack of research in cognition–personality interrelations in old age as well as with regard to factors underlying these relationships. Hence, an important step forward in developing a better understanding of the cognition–personality interrelations is to investigate underlying mechanisms (Curtis et al., 2015). Conceptually, developing a better understanding of the cognition–personality interrelations in old age is important for several reasons. First, it is of interest whether stabilities and changes in one domain (e.g., personality) are related to the other domain (e.g., cognition), because specific personality traits may (a) help older adults to maintain their cognitive levels as they age (Baker & Bichsel,

2006) or (b) serve as a source of vulnerability with regard to cognitive decline (Chapman et al., 2012). Similarly, cognition may be a prerequisite for personality traits to remain stable or to change in old age (cf. Moutafi, Furnham, & Crump, 2003). Knowing which domain has maintenance functions for the other domain may help to train or strengthen this particular domain. Second, existing cognitive or personality interventions may benefit from a better understanding of the cognition–personality interrelations in old age (cf. Stine–Morrow & Basak, 2011), as new insights could provide guidance to develop cognitive interventions for different personality types or personality interventions depending on cognitive characteristics (Graham & Lachman, 2014).

The present study investigated cognitive complaints as a potential underlying mechanism of the bidirectional longitudinal association between cognition and emotional stability across 12 years in healthy older adults. In terms of personality dimensions, we focus on emotional stability for two reasons. On the one hand, the association between cognition and emotional stability seems to be stronger in older than in younger adulthood based on cross–sectional comparisons (Soubelet & Salthouse, 2011). On the other hand, emotional stability may be particularly relevant for cognition in late life because it is considered as a protective factor against the development of mild cognitive impairment (Kuźma, Sattler, Toro, Schönknecht, & Schröder, 2011). In terms of our analytical approach, we examined the bidirectional longitudinal association between cognition and emotional stability mediated by cognitive complaints (see below for our rationale on why focusing on cognitive complaints as mediator). In general, the associations between cognition and personality are rarely analyzed bidirectionally, but this will provide important insights into whether the associations are similar or different. First, we tested whether cognition had an effect on emotional stability, and whether this effect is mediated by cognitive complaints.

Considering cognition as a predictor of personality traits has only been addressed by a few studies (e.g., Curtis et al. 2015, Wettstein et al., 2016), as previous research tended to focus on personality traits as predictors of cognition. Second, we tested whether emotional stability had an effect on cognition, and whether this effect is mediated by cognitive complaints.

Cognition and Emotional Stability

In the current literature, explanations for both directions, that is (a) how emotional stability influences cognition and (b) how cognition influences emotional stability are proposed. For (a), individuals low in emotional stability may experience more anxiety and be more prone to intrusive thinking that, in turn, may impair their cognitive performance in a testing situation (Gold & Arbuckle, 1990; Graham & Lachman, 2012; Moutafi, Furnham, & Tsaousis, 2006). Emotional stability is negatively related to anxiety on both the state (e.g., Moutafi et al., 2006) and trait level (e.g., Jylhä & Isometsä, 2006). Moreover, anxiety negatively affects cognitive performance in older adults (e.g., Salthouse, 2012; Stillman, Rowe, Arndt, & Moser, 2012). It has also been suggested that emotionally unstable individuals may perform worse on cognitive tasks due to distractive and worry–related thoughts (Gold & Arbuckle, 1990; Meier, Perrig–Chiello, & Perrig, 2002) or because of their easily aroused sympathetic nervous system (SNS; Biernacki & Tarnowski, 2011). Likewise, the activation of the hypothalamic–pituitary–adrenal (HPA) axis in response to stress releases hormones such as cortisol, adrenaline, and noradrenaline that can impair cognitive performance (e.g., Lupien, Maheu, Tu, Fiocco, & Schramek, 2007). Furthermore, it may be that chronic stress as experienced by individuals low in emotional stability could cause neuronal damage across time (e.g., Chapman et al., 2012; Jorm et al., 1993). In detail, individuals with lower levels of emotional stability experience more stress in their daily lives (e.g., Bolger & Schilling, 1991; Suls & Martin, 2005) that can lead to prolonged

activation of the HPA axis, and therefore excess glucocorticoids (hypercortisolemia). Consequently, hypercortisolemia can accelerate the rate of normative hippocampal atrophy (Sapolsky, 1994). In addition, emotional instability is positively related to a decline in brain volume (e.g., Jackson, Balota, & Head, 2011). For (b), it may be that decline in cognitive ability causes older adults to become more anxious, with increasing anxiety related to lower emotional stability (Curtis et al., 2015).

The existing body of cross–sectional research on the association between cognition and emotional stability suggests that higher emotional stability is linked with better cognitive performance (see Curtis et al., 2015, for a review). The correlation coefficients that have been reported for associations between different measures of cognition and emotional stability ranged from .16 to .50 (cf. Curtis et al., 2015; Gow, Whiteman, Pattie, & Deary, 2005). Although several studies found links between cognition and emotional stability, other studies did not find significant associations between the two domains (e.g., Jelicic et al., 2003; Salthouse, 2014; Wetherell, Reynolds, Gatz, & Pedersen, 2002). Only very few studies have examined this association longitudinally. Lower emotional stability was associated with faster global cognitive decline over six years (e.g., Wilson et al., 2003; Wilson et al., 2007). Chapman et al. (2012) showed that lower emotional stability was related to worse average cognitive functioning seven years later. Nevertheless, other longitudinal studies reported no significant associations between emotional stability and cognition (e.g., Hultsch, Hertzog, Small, & Dixon, 1999; Jelicic et al., 2003; Wetherell et al., 2002).

To sum up, previous cross–sectional research demonstrated some significant associations between cognition and emotional stability in old age, whereas longitudinal studies are very sparse and the existing results are inconsistent. This inconsistency may be due to differences in

methodology across studies, the use of specific populations, the age range within late life considered, the analytic approach, covariates included, and the length of the time interval (cf. Luchetti, Terracciano, Stephan, & Sutin, 2016). Importantly, the question of what mechanisms may drive such a longitudinal relation (and therefore also possibly explain the disparate pattern) remains virtually unaddressed.

Underlying Mechanisms between Cognition and Emotional Stability

Although existing cross–sectional research has established a negative association between low emotional stability and cognition in healthy older adults, little is known about the mechanisms that underlie this relationship even from a cross–sectional perspective. In a sample of young and middle–aged adults, emotional stability was no longer related to intelligence when the effects of test anxiety were removed (Moutafi et al., 2006). Furthermore, it has been shown that individual differences in intrusive thoughts mediated the relationship between emotional stability and performance on attention–demanding cognitive tasks beyond negative affect (Munoz, Sliwinski, Smyth, Almeida, & King, 2013). However, the mean age of this sample was 49 years. Moreover, it has been hypothesized that need for cognition may mediate the relationship between emotional stability and intelligence, with a lack of motivation for cognitive challenge being the link between lower emotional stability and lower intelligence (Furnham, & Thorne, 2013). This means, individuals low in emotional stability tend to avoid cognitive challenges that lead to the development of intellectual abilities, or individuals with a strong motivation for cognitive challenge are not affected by test anxiety that impairs the performance of individuals with lower emotional stability on cognitive tests (Moutafi et al., 2006). In contrast to their expectations, Furnham and Thorne (2013) did not find a significant link between

emotional stability and intelligence in a sample of undergraduate students, thus failing to test a possible mediation effect of need for cognition.[1]

So far, very few studies have examined potential mechanisms between cognition and emotional stability. Beyond that, the generalizability of these results is restricted to cross–sectional data and to young as well as middle–aged samples. To our knowledge, there is only one study that addressed these limitations and examined whether sensory impairment moderated the (cross–sectional and) longitudinal relationship between cognition and emotional stability in advanced old age, that is 72 to 95 years (Wettstein et al., 2016). These results suggest that lower emotional stability was associated with worse cognitive performance four years later in sensory impaired individuals, even after controlling for cognition at baseline, age, education, and chronic conditions. Overall, the mechanisms underlying the association between cognition and emotional stability remain largely uninvestigated. Therefore, our research question revolves around testing a longitudinal mediation design, whether cognitive complaints mediate the association between cognition and emotional stability.

Cognitive Complaints as a Potential Mechanism

Cognitive complaints are negative judgments about one's cognitive performance (Mascherek, Zimprich, Rupprecht, & Lang, 2011). Studies over the past two decades have demonstrated that cognitive complaints increase (e.g., Abson & Rabbitt, 1988; Zarit, Cole, & Guider, 1981), whereas actual cognitive performance on average decreases with advancing age (e.g., Lindenberger, & Baltes, 1994; McDonald–Miszczak, Hertzog, & Hultsch, 1995; Schaie,

[1]Because the present data set did not include test anxiety, intrusive thoughts, need for cognition or information about the arousal of the sympathetic nervous system or hypothalamic–pituitary–adrenal axis, it was not possible to test for these alternative mediators.

1996). Therefore, cognitive complaints might be a mechanism that underlies this relationship particularly in old age.

Studies on the relationship between subjective cognitive complaints and objective cognitive performance have given inconclusive results. Some studies found small to moderate relationships between the two constructs (e.g., McDonald–Miszczak et al., 1995), whereas others did not find any association (e.g., Jorm et al., 1997). Nevertheless, these complaints are often interpreted as indicators of cognitive decline (Dufouil, Fuhrer, & Alpérovitch, 2005) and age–related cognitive disorders such as Alzheimer's disease and other forms of dementia (Jonker, Geerlings, & Schmand, 2000; Paradise, Glozier, Naismith, Davenport, & Hickie, 2011). As such, cognitive complaints have become a key element of several diagnostic concepts aiming to identify older adults who might be at a risk of cognitive decline (e.g., Kliegel & Zimprich, 2005; Levy, 1994). Moreover, cognitive complaints could be linked to emotional stability (e.g., Kliegel & Zimprich, 2005; Wilhelm, Witthöft, & Schipolowski, 2010). Individuals low in emotional stability may negatively color self–judgments in general and cognitive performance (Mascherek et al., 2011). This is consistent with the "complaint hypothesis" (Wilhelm et al., 2010), suggesting that higher complaints reflect to some extent poor self–image or lack of confidence. In turn, poor self–image and lack of confidence may reflect inappropriate general worry and objectively unjustified complaints that are at least partly irrespective of the frequency or intensity of cognitive failure episodes (Wilhelm et al., 2010).

Taken together, both cognition as well as emotional stability are associated with cognitive complaints. Moreover, previous studies also reported links between cognition and emotional stability as stated earlier. This means, previous research has shown evidence for three links separately, that is between (a) cognition and cognitive complaints, (b) emotional stability and

cognitive complaints as well as (c) cognition and emotional stability. We aimed to bring these links together by investigating them in a longitudinal mediation design. As emotional instability may serve as a source of vulnerability concerning lower cognition (cf. Chapman et al., 2012), and cognition may be a prerequisite for emotional stability to remain stable or to change in old age (cf. Moutafi et al., 2003), we examined cognitive complaints as a possible underlying mechanism of this bi–directional relationship.

There are several reasons how or why cognitive complaints might mediate the longitudinal association between cognition and emotional stability and vice versa. For example, it might be that individuals with poorer cognitive test performance may be more prone to report cognitive complaints. It is reasonable to assume that poorer cognition is associated with confusing or forgetting names, phone numbers or reporting difficulties in planning or concentrating (e.g., Dufouil et al., 2005; McDonald–Miszczak et al., 1995). Among these individuals, the experience of cognitive complaints may influence their emotional stability. To be more specific, individuals who make more negative judgments about their cognition (i.e., higher levels of cognitive complaints) may experience more negative emotions such as anger or anxiety, and to be emotionally unstable (i.e., lower levels of emotional stability). Moreover, it might be that older individuals with lower cognition develop cognitive complaints over time because they have more difficulties to cope with circumstances as well as individuals with higher levels of cognition, resulting in being emotionally unstable. Together, these explanations support the assumption that cognition is a prerequisite for personality traits such as emotional stability to remain stable or to change in old age (cf. Moutafi et al., 2003). Furthermore, it might be that individuals with lower emotional stability are more likely to focus on cognitive problems rather

than on successful episodes (Ponds & Jolles, 1996) which then actually leads to poorer cognitive performance.

Based on this reasoning, we expected that cognitive complaints mediate the effect of cognition (predictor) on emotional stability (outcome). We hypothesized that individuals with poorer cognitive test performance report more cognitive complaints what is negatively related to their emotional stability. On the other hand, the alternative pattern can also be predicted based on the available literature; namely that cognitive complaints mediate the effect of emotional stability (predictor) on cognition (outcome). Here, it would be expected that individuals with lower emotional stability are more prone to experiencing cognitive complaints that may impair their cognitive test performance.

Goals of the Present Study

The present study investigated whether cognitive complaints mediate the effect of cognition on emotional stability and vice versa over 12 years. First, we tested whether cognition had an effect on emotional stability, and whether this effect is mediated by cognitive complaints. Second, we tested whether emotional stability had an effect on cognition, and whether this effect is mediated by cognitive complaints. Figure 1 shows the two scenarios through which mediation was tested. We tested the mediation models longitudinally. In contrast to cross–sectional mediation models, longitudinal mediation models account for the temporal structure that is required to test mediation (cf. Infurna & Mayer, 2015). Cross–sectional mediations would be unable to determine whether cognition influences emotional stability or emotional stability influences cognition or whether both are just interrelated due to other common causes. Hence, cross–sectional mediation can inflate the estimates of mediation and does not provide an accurate picture of mechanisms underlying developmental processes (e.g., Infurna & Mayer, 2015;

Maxwell & Cole, 2007). Furthermore, it is important to test longitudinal mediation as the mediator cannot be concurrent with the predictor and must precede the outcome (Lindenberger, von Oertzen, Ghisletta, & Hertzog, 2011; MacKinnon, Fairchild, & Fritz, 2007). Moreover, the mediation model makes theoretical claims about causality; therefore, it requires causally unbiased effects (e.g., Cole & Maxwell, 2003; Infurna & Mayer, 2015; Judd & Kenny, 1981), or in other words, possible confounders need to be considered. An advantage of longitudinal designs is to control for one of the most ubiquitous possible confounders, namely prior levels of the dependent variable (Gollob & Reichardt, 1991). For example, when predicting emotional stability at Time 3 from cognition at baseline (Time 1), regression cannot be used to draw conclusions if there are any unmeasured and uncontrolled exogenous variables that correlate with cognition (predictor) and influence emotional stability (outcome). Similarly, in longitudinal mediation models, one must control for the dependent and mediator variable at baseline (Cole & Maxwell, 2003). Otherwise, the estimates of the path of interest will be spuriously inflated.

Methods

Participants

We used archival data from the Interdisciplinary Longitudinal Study on Adult Development (ILSE; e.g., Allemand, Schaffhuser, & Martin, 2015; Allemand, Zimprich, & Martin, 2008; Sattler et al., 2015) to examine our research goals. The study was carried out in accordance with the Declaration of Helsinki and approved by the ethics committee of the University of Heidelberg. In ILSE, participants come from two age cohorts, one including individuals born in 1930–1932, and the other comprised of individuals born in 1950–1952. The observation period of ILSE was 12 years, including three measurement occasions. The assessments were conducted in 1994 (Time 1; T1), 1998 (Time 2; T2), and 2006 (Time 3; T3).

For the current study, only individuals from the older cohort (i.e., born in 1930–1932) were included as our focus was on old age. The first data wave (T1) consisted of 500 older adults (born in 1930–1932). Thereof, 300 individuals participated at all three measurement occasions and had complete data records for the variables of interest. For the current data analyses, we included all 500 participants and accommodated missing data using Full Information Maximum Likelihood estimation procedures.[2] At T1, the mean age of the sample was 62.97 years (*SD* = 0.91, range = 60–64 years; 52% male). Of the participants, 71.8% were married, 2% lived with a partner, 10.2% were widowed, 8.2% were divorced, 1.6% were separated, 5% were single, and 1.2% did not report on their marital status. The mean level of education was 1.52 (*SD* = 0.91), whereas education was assessed with an ordinal variable including the years of education (1 = *<10 years*, 2 = *11–12 years*, 3 = *13–15 years*, 4 = *>15 years*). The mean of depressive affect was 1.73 (*SD* = 0.36) on a scale ranging from 1 (never) to 4 (always). On average, participants reported no problems with sensory functioning (i.e., hearing and vision; *M* = 0.84*, SD* = 0.13, scale = 0–1). Furthermore, average objective health was 4.53 (*SD* = 0.88) on a scale from 1 (very bad) to 6 (very good). The mean of subjective health was 3.40 (*SD* = 1.44) on a scale from 1 (insufficient) to 6 (very good).

To test for differences between those who dropped out and those who continued the study, dropouts (*n* = 200) were compared with continuers (*n* = 300). Continuers were slightly more satisfied with their health (Cohen's *d* = .30), more emotionally stable (*d* = .20), and they reported less depressive affect (*d* = –.25) than dropouts. Furthermore, continuers showed slightly better performance in the cognitive tasks Picture Completion (*d* = .22), Block Design (*d* = .37), Spatial Ability (*d* = .40), Information (*d* = .33) than dropouts. There was a group difference with

[2] We also ran all analyses including only the 300 individuals who participated at all three measurement occasions and had complete data records for the variables of interest. The results changed minimally, but not concerning the gist. These results are available upon request.

respect to the cognitive task Similarities with continuers showing a better sum score (d = .55). The groups did not significantly differ regarding their age (d = .15), education (d = .10), and cognitive complaints (d = .11). Although continuers and dropouts differed significantly in most variables (except for age, education, and cognitive complaints), these differences reflect small effects (except for the cognitive task Similarities which reflects a moderate effect; Cohen, 1988). Attrition is a well–known problem in aging research (e.g., Lindenberger, Singer, & Baltes, 2002; McArdle, Hamagami, Elias, & Robbins, 1991; Siegler & Botwinick, 1979), and it should be noted that selectivity bias in longitudinal studies of older adults may represent selectivity processes of late life where those with lower cognition, lower resource capacities and more health problems die earlier.

Measures

Cognition. We investigated cognition on a general level by considering established cognitive tests covering a broad range of cognitive functions. Cognition was assessed using five different manifest indicators, namely, Picture Completion, Block Design and Spatial Ability, Information, and Similarities.

First, the Picture Completion task is a subtest of the German Wechsler Adult Intelligence Scale–Revised (WAIS–R; Tewes, 1991). Participants were required to mention details that were missing on 17 pictures of simple objects (e.g., a car with a missing wheel). Participants were given 20 seconds to mention the missing detail for each picture. Correct answers were scored with one point. Correct answers were added to form a total score of Picture Completion (possible range: 0–17).

Second, the Block Design task is a subtest of the WAIS–R (Tewes, 1991). Participants were required to reproduce abstract patterns using nine colored blocks within a given maximum

time limit. For every correct solution within the maximum time limit, two or four points were scored (depending on the complexity of the abstract pattern). Two or three additional points (depending on the complexity of the pattern) were given if the time to reproduce the pattern correctly fell below certain time limits. The nine item scores were added to form a total score of Block Design (possible range: 0–51).

Third, the Spatial Ability task consists of geometrical figures taken from the German test battery "Leistungsprüfsystem" (LPS; Horn, 1983). Participants were required to count the number of surfaces in 40 different three–dimensional images of geometrical figures. Participants were given three minutes to work on the task. Correct answers were scored with one point. Correct answers were summed to form a total score of Spatial Ability (possible range: 0–40).

Fourth, the Information task is a subtest of the WAIS–R (Tewes, 1991). Participants were required to answer a total of 24 questions from different knowledge domains (e.g., what is an ode?). Correct responses were scored with one point. Correct responses were summed up to form a total score of Information (possible range: 0–24).

Fifth, the Similarities task is a subtest of the WAIS–R (Tewes, 1991). Participants were required to name what two concepts had in common (e.g., zoo and library). In total, there were 16 pairs of concepts. Correct solutions were scored with one or two points depending on the quality of the answer. Correct answers were added to form a total score of Similarities (possible range: 0–32).

The estimates of internal consistency (Cronbach's alpha) of the general cognition factor based on the sample of 500 participants were as follows: .82 (T1), .82 (T2), and .80 (T3). The omega hierarchical estimates (Zinbarg, Revelle, Yovel, & Li, 2005) were .73 (T1), .77 (T2) and, .69 (T3). The internal consistencies of cognition ranged from acceptable to good.

Cognitive complaints. Subjective cognitive complaints were measured with six items from the Nuremberg Self–Assessment List (NSL; Oswald & Fleischmann, 1995). These six items assess cognitive problems and were selected based on previous literature (cf. Martin & Zimprich, 2003; Mascherek & Zimprich, 2011). Participants were asked to report cognitive problems in several domains of everyday life (e.g., confusing names, phone numbers, dates or having difficulties to follow the train of thought of others). Items were rated on a 4–point Likert–type scale ranging from 1 (completely wrong) to 4 (completely true). The estimates of internal consistency (Cronbach's alpha) were as follows: .76 (T1), .83 (T2), and .81 (T3). The omega hierarchical estimates (Zinbarg et al., 2005) were .61 (T1), .71 (T2), and .67 (T3). The internal consistencies of cognitive complaints ranged from acceptable to good.

Emotional stability. Emotional stability was measured using 12 items of the German version of the NEO–Five–Factor Inventory (NEO–FFI; Borkenau & Ostendorf, 1993). The items were rated on a 5–point Likert–type scale ranging from 0 (strongly disagree) to 4 (strongly agree). Cronbach's alpha were .77 (T1), .80 (T2), and .80 (T3), whereas the omega hierarchical estimates (Zinbarg, et al., 2005) were .61 (T1), .68 (T2), and .65 (T3). The internal consistencies of emotional stability ranged from acceptable to good.

Potential confounders. We included gender, depressive affect, sensory functioning, objective and subjective health as potential confounders because they share common associations with cognition, cognitive complaints and emotional stability (e.g., Kliegel & Zimprich, 2005; Kliegel, Zimprich, & Eschen, 2005, Wettstein et al., 2016). The inclusion of confounders allows to more stringently testing the mediation effects, thus enhancing the robustness of the results. *Gender* was coded as 0 for male, and 1 for female. *Depressive affect* was measured using a 20–item self–rating depression scale (SDS; Zung & Zung, 1986). The items were rated on a 4–point

Likert–type scale ranging from 1 (never) to 4 (always). Cronbach's alpha was .78 (T1), the omega hierarchical estimate (Zinbarg et al., 2005) was .53 (T1). The internal consistencies of depressive affect ranged from acceptable to good. *Sensory functioning* consisted of two items concerning participants' hearing and vision (i.e., "Did you or do you have problems with hearing?", and "Did you or do you have problems with your vision?"). A dichotomous scale (0, 1) was used for both items. A mean score of the two items was created where lower scores indicate sensory impairment. *Objective health* comprised an anamnesis, a blood analysis, a geropsychiatric assessment, and a medical checkup conducted by one to two trained study geriatricians (see Miche, Elsässer, Schilling, & Wahl, 2014, for more details). The professionals aggregated the data and rated the participants' state of health on 6–point scale. Answer options ranged from 1 (very bad) to 6 (very good). *Subjective health* was measured with one item where participants rated their current health situation 1 (insufficient) to 6 (very good). For all potential confounders, we used data from T1, and included them as manifest variables in the analyses.

Statistical Procedures

Our statistical analyses consisted of several steps. First, we established longitudinal measurement models. Second, we tested these models for longitudinal measurement invariance. Third, we ran the longitudinal mediation models (a) without and (b) with confounders.

Longitudinal measurement models. We used longitudinal structural equation modeling (SEM; McArdle & Nesselroade, 2014) to investigate our research goals. First, longitudinal measurement models were established for cognition, cognitive complaints, and emotional stability. Cognition was estimated as a latent construct consisting of five manifest indicators (i.e., cognitive tasks as mentioned earlier) at each measurement occasion. For cognitive complaints and emotional stability, parcels were created to form manifest indicators following the item–to–

construct balance technique (Little, Cunningham, Shahar, & Widaman, 2002). Correlated residual variances were allowed for the matching parcels at T1, T2, and T3 (Marsh & Hau, 1996).

Longitudinal measurement invariance. To ensure that the latent constructs of interest are comparable over time (Meredith & Horn, 2001), longitudinal measurement invariance (MI) of the latent measures of cognition, cognitive complaints, and emotional stability was established. As old age is a phase of susceptibility to individual and environmental changes as well as non–normative events (Baltes, Lindenberger, & Staudinger, 2006), it seems particularly important to establish MI. It may be that participants tend to change their internal standards of perceptions across 12 years, because of accompanying changes that aging brings with it. Our goal was to establish strong MI (Little, 2013). We first tested an unconstrained measurement model of configural invariance (M1) that longitudinally specified the relationship between manifest indicators and the latent constructs. Second, a model of weak MI (M2) was tested by setting the factor loadings equally over time. The factor variances were freely estimated over time. Third, a model of strong MI (M3) was tested which requires equal factor loadings and equal indicator intercepts over time. The factor means were freely estimated over time. Establishing strong MI allows for meaningfully comparisons of means, covariances, and variances over time.

Longitudinal mediation. The mediation model offers an explanation how or why two variables are related, where a mediating variable is hypothesized to be intermediate in the association between a predictor and an outcome (Fairchild, MacKinnon, Taborga, & Taylor, 2009). In mediation analysis, three types of effects are commonly discussed: total effects, direct effects, and indirect effects (cf. Cole & Maxwell, 2003). The total effect is the sum of the direct

and indirect effects. Direct effects refer to the effects of the predictor on the outcome. Indirect effects refer to the role of a third variable in mediating the effect of the predictor on the outcome. First, we considered longitudinal mediation models without confounders. Second, we considered possible confounders to determine whether temporal ordering and other variables influenced the associations. We included the previous assessments of the mediator and outcome variable, depressive affect, gender, sensory functioning, objective and subjective health as potential confounders.

In addition to *p*–values, we also provide 95% confidence intervals (CI) when reporting the longitudinal mediation models. CIs contain information about the size of an effect and its precision, thus being more informative than *p*–values alone (Cohen, 1994). CIs for total, direct, and indirect effects in all mediation models are based on bias–corrected bootstrapping (number: 10,000; see MacKinnon, Lockwood, & Williams, 2004). The scores of our variables of interest were converted into *z* scores (e.g., Schaie, Willis, & Caskie, 2004; Soubelet & Salthouse, 2010, 2011) to facilitate the comparison between different cognitive data types and self–report scales. Analyses were conducted with Mplus 7 (Muthén & Muthén, 1998–2015), and we applied full information maximum likelihood (FIML). To evaluate goodness of fit of the models, the chi–square (χ^2), comparative fit index (CFI), and root mean square error of approximation (RMSEA) as well as its 90% CIs were examined. CFI values above .97 and RMSEA values below .06 are considered to reflect a good fit, whereas CFI values above .93 and RMSEA values below .08 are acceptable (Browne & Cudeck, 1993; Byrne, 1994; Hu & Bentler, 1998). The model comparison was based on the standard fit indices RMSEA, CFI, standardized root-mean-square residual (SRMR), and Tucker Lewis Index (TLI).

Results

Longitudinal Measurement Invariance

Table 1 presents descriptive statistics and zero–order correlations among the variables of interest at T1 and T3. For cognitive complaints, data from T2 were correlated with the variables of interest, as it is the measurement occasion of interest concerning the longitudinal mediation. To establish MI of our latent measures, we first started with the least restrictive model (M1: Configural invariance) that constrains manifest indicators to load on the same factor over time. As shown in Table 2, all models achieved acceptable fits as judged by the CFI and RMSEA. Second, factor loadings were constrained to be equal over time (M2: Weak invariance). These more restrictive models achieved acceptable fits too. Furthermore, they did not significantly differ from M1 as reflected by the nested chi–square difference in Table 2. Next, the intercepts of the manifest indicators were constrained to be equal over time (M3: Strong invariance). In turn, the models achieved acceptable fits. The M3 models of cognition, cognitive complaints, and emotional stability did not significantly differ from M2. These results indicate that strong MI holds over time with respect to all latent measures. Thus, factor loadings and indicator intercepts of cognition, cognitive complaints, and emotional stability remained invariant across time.

Longitudinal Mediation Models

Results of the two[3] longitudinal mediation models are shown in Table 3 and 4. Bias–corrected bootstrapped confidence intervals are only available for the unstandardized (but not for the standardized) results of the models (Muthén & Muthén, 1998–2015, p. 727). Thus, we report both unstandardized and standardized estimates and standard errors, and bias–corrected

[3]A more elegant analytic approach might be to simultaneously include all variables in one model. Because the model fit of the simultaneous model was not acceptable, we decided to test two separate models including a model comparison based on the model fit indices.

bootstrapped confidence intervals for unstandardized results. In addition, we standardized the effects of the unstandardized results in order to report effect sizes. These effect sizes were taken by dividing the effect estimate by the standard deviation of the outcome variable (MacKinnon, 2008; Infurna & Mayer, 2015). Last, we compared the models (emotional stability–cognition model with covariates vs. cognition–emotional stability model with covariates) based on their fit indices.

Effects of cognition on emotional stability. Table 3A shows the effects of cognition on emotional stability without confounders. The total effect of cognition on emotional stability was 0.53, $SE = 0.09$, $p < .000$. The effect size was medium to large. Lower levels of cognition were associated with lower levels of emotional stability over 12 years. The effect size of the direct effect of cognition on emotional stability was in the small to medium range. We also observed that cognitive complaints did mediate the effect of cognition on emotional stability (indirect effect = 0.13, $SE = 0.04$, $p < .000$), but that the effect size was small (0.17).

Table 3B shows the results of the effects of cognition on emotional stability with confounders. Similar to the previous model, we found a significant total as well as direct effect when we accounted for confounders (total: 0.22, $SE = 0.08$, $p < .01$; direct: 0.18, $SE = 0.07$, $p < .01$). Both effect sizes were small. On average, showing lower levels of cognition was associated with reporting less emotional stability 12 years later. Cognitive complaints did mediate this effect (indirect effect = 0.04, $SE = 0.02$, $p < .05$). The effect size was 0.05, suggesting that although cognitive complaints mediated the effect of cognition on emotional stability, the strength or evidence of the link is very small.

Effects of emotional stability on cognition. Results of the longitudinal mediation models without and with confounders are shown in Table 4A and 4B. We found a significant total effect

of emotional stability on cognition without taking confounders into account (0.36, *SE* = 0.09, $p <$ .000). The effect size was medium. Furthermore, a significant direct effect was found (0.29, *SE* = 0.11, $p < .01$) with an effect size in the small to medium range (0.41). Lower levels of emotional stability were related to lower levels of cognition. However, cognitive complaints did not mediate this association (indirect effect: 0.07, *SE* = 0.06). When testing the total and direct effects of emotional stability on cognition in the appropriate longitudinal model that accounted for temporal ordering and prior confounds, both effects were reduced to non–significance (see Table 4B). Because the total and direct effects were not significant, the indirect effect was neither.[4]

Model comparison. To compare which model fits better, we checked the model fit indices of both models. The models did not differ with regard to RMSEA, but the cognition–emotional stability model yielded better values of CFI, SRMR, and TLI. However, these differences were minimal and the inference could not be secured statistically. Therefore, it cannot be concluded that one model fits the data better than the other.

Discussion

The aim of this study was to examine the bidirectional association between cognition and emotional stability and the mediating effect of cognitive complaints in healthy older adults. Two possible predictions were tested and then compared. First, we tested whether older individuals with poorer cognitive test performance show lower levels of emotional stability 12 years later and whether this effect is mediated by cognitive complaints. This pattern was confirmed by testing a longitudinal mediation model that controlled for baseline emotional stability, baseline

[4]A reviewer suggested to test the mediation models for all Big Five personality traits. Hence, we tested two longitudinal mediation models (both directions) for each trait separately. The results are available upon request. In summary, we had to reject some models due to their unacceptable model fits, and we found no significant total, direct or indirect effects at all.

cognitive complaints, depressive affect, gender, sensory functioning, objective and subjective health. Second, we tested whether older individuals with lower levels of emotional stability show poorer cognitive test performance 12 years later and whether this effect is mediated by cognitive complaints. In contrast to the previous pattern, our findings do not support a mediation effect of cognitive complaints on the relationship between emotional stability and cognition. Several important conceptual conclusions are suggested by those findings.

The finding that lower levels of cognition are associated with lower levels of emotional stability over 12 years is per se informative, because far very little attention has been paid to cognition as a predictor of emotional stability in old age (e.g., Curtis et al. 2015, Wettstein et al., 2016). Moreover, this finding is consistent with the lifespan developmental theory suggesting that lifespan dynamics of an increasingly negative gain–loss ratio in cognition (Baltes & Baltes, 1990) constitute a key factor for personality development (Wagner et al., 2016). Furthermore, cognitive complaints mediate the link between cognition and emotional stability. A possible explanation for this finding may be that compromised cognitive resources constrain and contribute to more cognitive complaints, thus leading to lower emotional stability. For example, older individuals with lower levels of cognition may have more difficulties to cope with situations that require cognitive resources in daily life. To illustrate, these individuals find it difficult to concentrate on reading the newspapers and complain about their ability to concentrate. Related to these complaints, they report lower levels of emotional stability. This explanation supports the assumption that reduced cognitive reserve capacity can be expected to shape personality trait development later in life (Wagner et al., 2016). Our results highlight the importance of investigating cognition as a predictor of personality traits in old age. Not only emotional instability may be a risk factor for cognitive decline (e.g., Luchetti et al., 2016) or

dementia (e.g., Low, Harrison, & Lackersteen, 2013), cognitive resources may also serve as a protective factor for emotional stability in late life.

Regarding the effect size, the strength of the mediating effect of cognitive complaints was relatively weak. However, it should be noted that the associations between cognition and personality are rather weak in general (e.g., Aschwanden, Martin, Allemand, 2017), and the investigated time interval of 12 years was relatively long with regard to this matter. Furthermore, also small effects can have consequences, and hence merit the attention to be investigated (Ozer & Benet–Martínez, 2006; Roberts, Kuncel, Shiner, Caspi, & Goldberg, 2007).

A practical implication based on our findings might be that individuals with poorer cognitive functioning and reporting cognitive complaints should be identified, because they are at risk for experiencing lower emotional stability. Cognitive interventions may help to maintain cognition (cf. Kelly et al., 2014) and everyday functioning (e.g., Gross, Rebok, Unverzagt, Willis, & Brandt, 2011), and thus have positive side effects on personality traits (e.g., Jackson, Hill, Payne, Roberts, & Stine–Morrow, 2012; but see also Sander, Schmiedek, Brose, Wagner, & Specht, 2017) such as emotional stability. Specifically, a combined cognitive–personality intervention that improves cognitive performance and reduces cognitive complaints may be successful to maintain emotional stability in old age. For family members and friends, it might be easier to observe cognitive complaints than lower cognition in daily life. Therefore, cognitive complaints may represent an identifier of those who are at risk of experiencing lower emotional stability due to their cognitive functioning. Moreover, interventions may consider identifying at–risk individuals by using cognitive complaints' surveys or interviews. The target of the intervention would be on cognitive performance as it precedes cognitive complaints (i.e., cognitive training). At the same time, older individuals should be encouraged to preventively

work on their emotional stability because it is influenced by cognitive complaints (i.e., personality intervention). Furthermore, emotional stability was found to be the primary trait domain of all Big Five traits showing changes as a result of interventions (Roberts et al., 2017). This combined approach could be implemented within a computer–based or smartphone–based intervention at home. For instance, individuals would solve cognitive tasks and engage in exercises that are tailored to enhance emotional stability behaviors every morning. The cognitive training should be adaptive at skill levels with the goal that individuals would feel challenged but not overwhelmed (Payne, Jackson, Noh, & Stine–Morrow, 2011). The emotional stability exercises could include simple tasks such as doing something good for oneself or reappraise a negative experience. Short interventions, lasting days rather than weeks, may be unlikely to improve cognition and to change emotional stability. Future research is required to establish the applicability of a combined cognitive–personality intervention and its duration to be effective, especially in view of the small effect size of the mediating effect of cognitive complaints. But the first and critical step, showing that the associations between cognition, cognitive complaints and emotional stability are evident not only in separate models but also in a longitudinal mediation design, has now been taken.

With regard to the inverse direction, lower levels of emotional stability are related to lower levels of cognition 12 years later when ignoring possible confounders. Contrary to possible predictions, cognitive complaints are not the underlying mechanism by which the relationship between emotional stability and cognition occurs. Although previous work suggested that individuals low on emotional stability may negatively color self–judgments in general and cognitive performance (e.g., Mascherek et al., 2011), our results suggest that individuals with lower emotional stability are not more prone to experiencing cognitive complaints and thus

showing poorer cognitive performance. There are two likely explanations. First, our sample consisted of healthy, cognitively non–impaired individuals. It is possible that a longitudinal association between emotional stability, cognitive complaints and cognition is only evident in individuals who suffer from mild cognitive impairment or dementia. Put differently, it can be assumed that as long as individuals with lower emotional stability are healthy and report some minor cognitive hassles only, there is no longitudinal association, but it might be different for individuals who suffer from serious cognitive problems. It seems that poorer cognitive performance needs to be recognized first by the individual, before judging negatively about one's cognitive ability. Second, cognitive complaints are one of many possible mediators at play, such as test anxiety (Moutafi et al., 2006) and intrusive thoughts (Munoz et al., 2013), which show similar associations with cognition and emotional stability at least in young and middle–aged adults. Unfortunately, the present study did not include test anxiety or intrusive thoughts. For further studies, it may be useful to assess whether the effect of emotional stability on cognition is also mediated by these two factors in older adults. However, the effect of emotional stability on cognition vanished when we controlled for temporal ordering and prior confounds. This indicates that the effect is apparent when other variables are taken into account and supports previous research reporting null findings between emotional stability and cognition (e.g., Hultsch et al. 1999; Jelicic et al., 2003; Wetherell et al., 2002). We offer three possible explanations. First, it may be that the investigated time interval of 12 years was not appropriate regarding the nature of the effect of emotional stability on cognition. It is possible that the nature of the association differs between (a) cognition–emotional stability, and (b) emotional stability–cognition. For example, it may be that the time interval of 12 years was appropriate for cognition–emotional stability, but it may be shorter or longer for emotional stability–cognition because of different

mechanisms that may underlie the direction of these relations. So, the distance between measurement occasions must be chosen separately for the direction that will be investigated. Time intervals that are too long or too short can produce data that might be overly sensitive to measurement errors and carryover effects or insensitive to variability and change (cf. Hertzog & Nesselroade, 2003). Second, it may be that only specific facets of emotional stability are related to different cognitive abilities (cf. Luchetti et al., 2016; Wilson, Begeny, Boyle, Schneider, & Bennett, 2011). Using 12 items of the NEO–FFI (Borkenau & Ostendorf, 1993), we were not able to differentiate between facets, what is an important issue for future research. Third, a possible explanation could be that the effect of emotional stability on cognition is only present in later old age, but not in early old age. Hertzog, Kramer, Wilson, and Lindenberger (2009) pointed out that the mean age of studies observing an association between emotional stability and cognition was over 70 years, whereas studies finding no association investigated samples with a mean age under 70 years, consistent with the idea that the detrimental effects of psychological distress are cumulative and therefore most evident in later old age. Furthermore, the authors identified other factors that may be partly responsible for the null results in emotional stability–cognition literature, such as having fewer participants ($N < 500$) and lower follow–up participation (< 85%). Hence, the present study is characterized by all these factors (baseline age under 70, $N = 500$, follow–up participation rate < 85%) that may have contributed to find no effect of emotional stability on cognition.

From a methodological point of view, the effects of the associations of interest differed by the tested models. Concerning the mediating effect of cognitive complaints on the association between cognition and emotional stability, the effect size was relatively small across both models (without and with confounders). Nevertheless, it was clearly reduced when tested appropriately

with confounders. Moreover, we found no significant effect of emotional stability on cognition in the model with confounders. This shows that the effects and effect sizes are dependent on the type of design used, and emphasizes that temporal ordering and controlling for (prior) confounds need to be held for scientists to draw conclusions from mediation (Infurna & Mayer, 2015).

Limitations and Future Directions

The current study has a number of strengths, including the use of a late–life longitudinal sample, the consideration of cognition as a predictor, testing longitudinal mediation models, and identifying cognitive complaints as an underlying mechanism between cognition and emotional stability. Another important strength was that the sample represented a narrow age cohort (60–64 years at T1), meaning that our associations of interest could be associated with a very specific age range, and that the associations were not confounded by variation in chronological age. However, our study also has a number of limitations. We expect some constraints on the generalizability of our findings that we consider below in order to encourage appropriate conclusions and inform future replication attempts (cf. Simons, Shoda, & Lindsay, 2017). It might be that an unmeasured relevant confounder would change parts of our findings, although we attempted to include all relevant confounders in our longitudinal mediation models. Furthermore, it is possible that more than only one factor underlies the association between cognition and emotional stability. Such factors should be identified and included in future multiple mediation models, in addition to cognitive complaints to test and determine which are most pertinent. For instance, heightened hypothalamic–pituitary–adrenal axis activity might be such a factor because it can be linked to emotional stability and cognition (Wilson et al., 2011). Furthermore, chronic stress might be another factor that should be taken into account (Scott et

al., 2015).[5] Moreover, the present study examined whether levels in cognition were predicted by levels of emotional stability and vice versa. As such, we were interested "in the basics" of possible cognition–emotional stability relations, and we strictly met the requirements of a longitudinal mediation (the predictor must precede the mediator, the mediator must precede the outcome). Though, it would be interesting to focus on changes in cognition and emotional stability in future investigations. It may be that changes in emotional stability may be more predictive for cognition than levels of emotional stability at one point in time and vice versa. Latent change score (LCS) models (cf. Ferrer, & McArdle, 2010; McArdle, 2009) offer the possibility to test these ideas. Likewise, further studies are required to test whether emotional stability varies by different cognitive domains.

Regarding future replication attempts, we believe the results will be reproducible with healthy older adults from similar subject pools serving as participants, and using cognitive tasks and self–report emotional stability measures in the laboratory. We have no reason to believe that the results depend on other characteristics of the participants, materials, or context (cf. Simons et al., 2017).

Conclusion

Taken together, this study has shown that cognitive complaints mediate the relationship between cognition and emotional stability in only one direction. Our findings indicate that cognition precedes cognitive complaints, and cognitive complaints precede emotional stability, but not vice versa. Overall, this study strengthens the idea that even personality traits such as emotional stability that use to be relatively stable across the lifespan (e.g., Lucas, & Donnellan,

[5]As suggested in the review process, we included sensory functioning and objective health as possible mediators in addition to cognitive complaints. Results (available upon request) showed that neither the indirect effect of sensory functioning nor objective health was significant, but only the indirect effect of cognitive complaints for the cognition–emotional stability model.

2011) may be shaped by broad–based functional levels of cognition late in life, and that cognitive complaints play a role in terms of possible mechanisms. Cognitive complaints may serve as an identifier to prevent older adults from experiencing lower emotional stability if they could participate in an intervention. On the other hand, individuals low in emotional stability do not seem to be prone to experience cognitive complaints and therefore showing poorer cognitive performance 12 years later. Briefly, the present study contributes to the research field of the associations between cognition and personality by (1) considering cognition as a predictor of emotional stability, and (2) identifying cognitive complaints as a unidirectional mediator of this relationship in old age. Nevertheless, further studies need to be carried out to learn more about the longitudinal association between cognition and emotional stability and further potential underlying mechanisms.

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Table 1

Correlations and Descriptive Statistics for the Variables of Interest

Variables	1	2	3	4	5	6	7
1. Picture completion	–	**.48**	**.41**	**.52**	**.52**	**–.20**	**–.32**
2. Block design	**.48**	–	**.60**	**.42**	**.42**	**–.14**	**–.22**
3. Spatial ability	**.53**	**.65**	–	**.46**	**.43**	**–.19**	**–.31**
4. Information	**.57**	**.46**	**.49**	–	**.60**	**–.17**	**–.31**
5. Similarities	**.47**	**.45**	**.52**	**.58**	–	**–.14**	**–.24**
6. Cognitive complaints	**–.11**	**–.15**	**–.16**	**–.19**	**–.16**	–	**.50**
7. Emotional stability	**–.26**	**–.22**	**–.29**	**–.30**	**–.19**	**.46**	–
M (T1)	11.73	26.90	21.40	15.61	24.94	1.88	2.56
SD (T1)	3.86	8.17	6.56	4.81	5.50	0.65	0.58
M (T2)	12.00	24.29	20.48	16.00	24.09	2.00	2.51
SD (T2)	3.67	8.57	6.73	4.59	6.23	0.68	0.57
M (T3)	11.79	24.13	19.84	16.27	24.50	2.02	2.46
SD (T3)	4.08	8.11	6.86	4.49	6.03	0.70	0.56
Range	0–17	0–51	0–40	0–24	0–32	1–4	0–4

Note. N = 500. Correlations at T1 are reported below the diagonal, correlations at T3 are reported above the diagonal. For cognitive complaints (mediator), data from T2 was correlated with the variables of interest. Boldface correlations are statistically significant at $p < .05$ (or lower). Means (*M*), standard deviations (*SD*) and possible ranges of the variables of interest are shown in raw scores. The means for emotional stability are shown in reverse: Higher scores indicate lower levels of emotional stability and lower scores indicate higher levels of emotional stability.

Table 2

Longitudinal Measurement Invariance

Model	χ^2 (df)	CFI	RMSEA [90% CI]	$\Delta\chi^2$(df)	ΔModels
Variables					
Cognition					
M1: Configural invariance	207.84***(72)	0.97	0.06 [0.052, 0.071]		
M2: Weak invariance	216.57***(80)	0.97	0.06 [0.049, 0.068]	8.73 (8)	2–1
M3: Strong invariance	217.63***(88)	0.97	0.05 [0.045, 0.063]	1.06 (8)	3–2
Cognitive complaints					
M1: Configural invariance	31.33**(15)	0.99	0.05 [0.023, 0.070]		
M2: Weak invariance	32.81*(19)	0.99	0.04 [0.013, 0.060]	1.48 (4)	2–1
M3: Strong invariance	32.98 (23)	0.99	0.03 [0.000, 0.051]	0.18 (4)	3–2
Emotional stability					
M1: Configural invariance	20.66 (15)	1.00	0.03 [0.000, 0.054]		
M2: Weak invariance	22.11 (19)	1.00	0.02 [0.000, 0.045]	1.46 (4)	2–1
M3: Strong invariance	22.24 (23)	1.00	0.00 [0.000, 0.035]	0.12 (4)	3–2

Note. $N = 500$. χ^2 = chi–square; CFI = comparative fit index; RMSEA = root mean square error of approximation; 90% CI = 90% confidence intervals; $\Delta\chi^2$ = nested chi–square difference; Δdf = difference in degrees of freedom; ΔModels = comparison of models.

*$p < .05$, **$p < .01$, ***$p < .000$.

Table 3

Effects of Cognition on Emotional Stability

	Emotional stability: standardized results		Emotional stability: unstandardized results			
Effect of	Estimate	*SE*	Estimate	95% BCCI	*SE*	Effect size
			A: without confounders			
Cognition						
Total	0.478***	0.060	0.534***	[0.378, 0.720]	0.086	0.68
Direct	0.361***	0.065	0.403***	[0.247, 0.577]	0.083	0.51
Indirect	0.117***	0.033	0.131***	[0.062, 0.218]	0.039	0.17
			B: with confounders			
Cognition						
Total	0.202**	0.066	0.218**	[0.080, 0.373]	0.075	0.29
Direct	0.168**	0.064	0.181*	[0.047, 0.332]	0.072	0.24
Indirect	0.035*	0.016	0.037*	[0.010, 0.082]	0.018	0.05

Note. N = 500. BCCI = bias–corrected confidence intervals. Bias–corrected bootstrap sample size = 10,000. The total effect is the sum of the direct and indirect effects. Direct effects refer to the effects of cognition on emotional stability. Indirect effects refer to the role of cognitive complaints in mediating the effect of cognition on emotional stability. Confounders that were included in Part B were baseline levels of the dependent and mediator variable, depressive affect, gender, sensory functioning, subjective and objective health.

*p < .05, **p < .01, ***p < .000.

Table 4
Effects of Emotional Stability on Cognition

	Cognition: standardized results		Cognition: unstandardized results			
Effect of	Estimate	*SE*	Estimate	95% BCCI	*SE*	Effect size
			A: without confounders			
Emotional stability						
Total	0.335***	0.068	0.360***	[0.201, 0.533]	0.085	0.51
Direct	0.270**	0.095	0.290**	[0.088, 0.510]	0.107	0.41
Indirect	0.065	0.056	0.070	[–0.041, 0.205]	0.061	0.10
			B: with confounders			
Emotional stability						
Total	–0.067	0.077	–0.074	[–0.254, 0.092]	0.088	–0.10
Direct	–0.072	0.081	–0.080	[–0.269, 0.091]	0.092	–0.11
Indirect	0.005	0.081	0.005	[–0.011, 0.050]	0.013	0.01

Note. $N = 500$. BCCI = bias–corrected confidence intervals. Bias–corrected bootstrap sample size = 10,000. The total effect is the sum of the direct and indirect effects. Direct effects refer to the effects of emotional stability on cognition. Indirect effects refer to the role of cognitive complaints in mediating the effect of emotional stability on cognition. Confounders that were included in Part B were baseline levels of the dependent and mediator variable, depressive affect, gender, sensory functioning, subjective and objective health.

$^{**}p < .01$, $^{***}p < .000$.

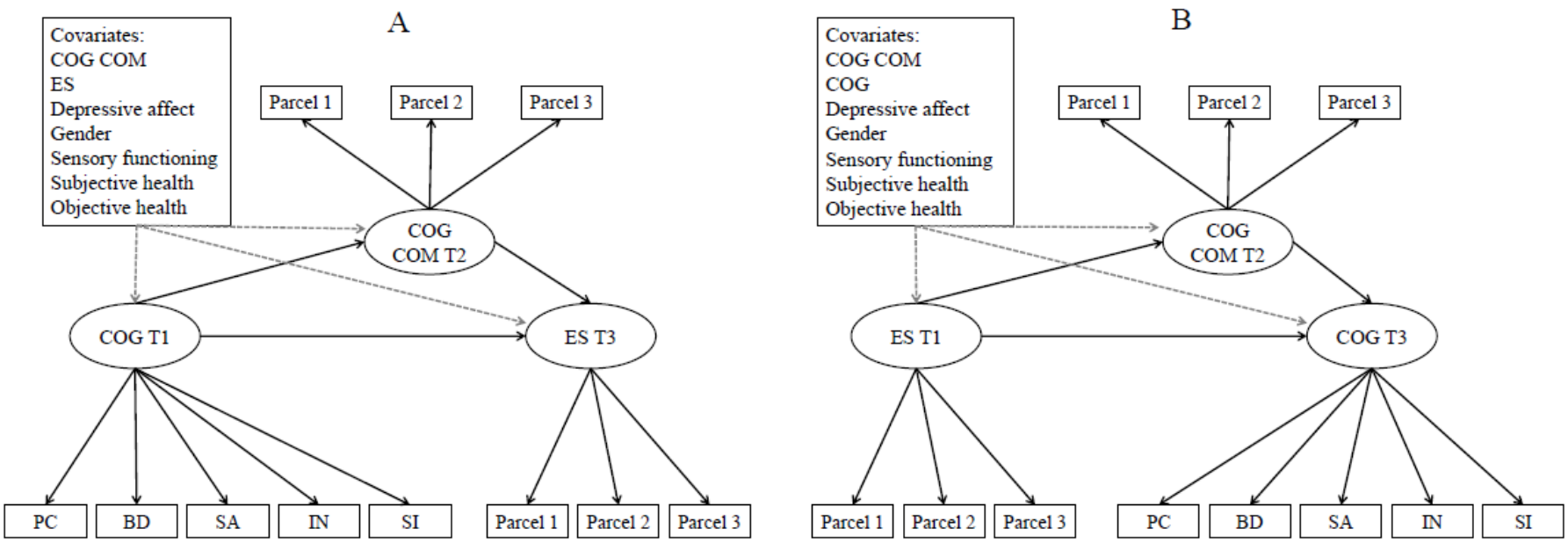

Figure 1. Simplified graphical illustration of the two longitudinal mediation models. COG = cognition, PC = picture completion, BD = block design, SA = spatial ability, IN = information, SI = similarities, COG COM = cognitive complaints, ES = emotional stability. When taking covariates into account, we controlled for baseline levels of the mediator and outcome variable, depressive affect, gender, sensory functioning, subjective and objective health.